CalTool™ for molbloc™

A PC Based Calibration Utility

For molbloc Flow Elements

User's Manual

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High pressure liquids and gases are potentially hazardous. Energy stored in these liquids and gases can be released unexpectedly and with extreme force. High pressure systems should be assembled and operated only by personnel who have been instructed in proper safety practices.

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ABOUT THIS MANUAL

Manual Conventions

This manual is intended to provide the user with the information necessary to use **CalTool for molbloc** software to adjust molbloc mass flow elements.

Before using the manual, take a moment to familiarize yourself with the table of contents structure. Do not attempt to use **CalTool for molbloc** for molbloc without using this manual to understand its principles and operation. Invalid molbloc calibrations can result from incorrect use of **CalTool**.

Certain words and expressions have specific meaning as they pertain to **CalTool**, molbloc and molbox. The Glossary Section (Section 7) is useful as a quick reference for definitions of specific words and expressions as they are used in the manual.

[ ] indicates **CalTool** menu, tab selections or icons (for example **[Data]**). Menu or tab selection paths are always described hierarchically from highest to lowest level. For example: **[Tools]**, **[Options]**.

< > indicates **COMPASS** text displays such as screen names, field names, prompts, warnings and instructions. For example: **<Enter user ID>**.

(CAUTION) is used in the manual to identify user warnings and cautions.

(NOTE) is used in the manual to identify operating and applications advice and additional explanations.

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1. INTRODUCTION

CalTool™ for molbloc™ is a PC based calibration utility intended to be used to adjust molbloc mass flow elements to agree with a mass flow reference at a particular operating pressure.

CalTool is run on a PC that is interfaced with a molbox1 or molbox RFM mass flow terminal.

CalTool runs mass flow intercomparisons, collects intercomparison data, calculates new molbloc calibration coefficients, predicts and displays test data with the new coefficients and writes new calibration coefficients to the molbloc.

molblocs and molbox are normally calibrated as independent elements. The molbox calibration consists of calibrating the molbox pressure transducers. See the molbox Operation and Maintenance Manual for molbox calibration information.

1.1 PRINCIPLES

1.1.1 HOW molbloc/molbox DETERMINES MASS FLOW

molbloc mass flow elements are laminar flow elements intended to be used with a molbox (molbox1 or molbox RFM) mass flow terminal. The molbox measures the temperature of the molbloc and the molbloc upstream and downstream pressures. Using the pressure and temperature information and gas characteristics stored in molbox memory, molbox calculates the density and viscosity of the flowing gas. From the density and viscosity of the flowing gas, the differential pressure across the molbloc and molbloc specific calibration coefficients stored on the molbloc EEPROM, molbox calculates the mass flow through the molbloc (see Figure 1).

The model used by molbox to calculate molbloc flow is proprietary. molbloc specific calibration coefficients are determined in the original factory calibration. Since the molbloc is a static, stainless steel element, the molbloc calibration coefficients are stable over time.

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$$qm = \frac{(P_1 - P_2)\rho_{(P,T)}}{\eta_{(P,T)}} \bullet C_{G(\mathrm{Re})}$$

Where:

$$\rho_{(P,T)} = \frac{P \bullet M}{Z_{(P,T)} \bullet R \bullet T} \qquad \mathrm{Re} = \frac{qm}{\pi \bullet \eta_{(P,T)}}$$

Determined by Measurement	Known from Gas Properties	Determined from Gravimetric Calibration
P_1	M	C_G
P_2	$Z_{(P,T)}$	
T	$\eta_{(P,T)}$	

And:

qm	=	mass flow	[kg/s]
P_1	=	upstream absolute pressure	[Pa]
P_2	=	downstream absolute pressure	[Pa]
P	=	$\frac{P_1 - P_2}{2}$	[Pa]
T	=	absolute temperature of gas	[k]
$\eta_{(P,T)}$	=	dynamic gas viscosity under P,T conditions	[Pa•s]
C_G	=	geometry of molbloc flow path and Reynolds number dependence	[m^3]
Re	=	Reynolds number	[-]
M	=	molecular weight of the gas	[g/mol]
$Z_{(P,T)}$	=	compressibility factor of the gas under P,T conditions	[-]
R	=	universal gas constant	$\left[\frac{J}{kg \bullet mol \bullet k}\right]$
r	=	radius of the piston	[m]

Figure 1. molbloc/molbox Mass Flow (qm) Determination

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1.1.2 RECALIBRATION OF molbloc/molbox

The molbox mass flow terminal and molbloc mass flow elements are calibrated separately.

Calibration of a molbox consists of calibrating the molbox pressure transducers and, possibly, verifying its ohmic measurement system which reads the molbloc platinum resistance thermometers. molbox calibration procedures are described in the molbox Operation and Maintenance Manual.

Calibration of a molbloc consists of comparing the mass flow measured by the combination of the molbloc and a calibrated molbox to a suitable mass flow standard flowing the gas for which the calibration is being performed. Since the molbloc is a static, stainless steel element, characterized by proprietary calibration coefficients determined in the original factory calibration, an out of tolerance molbloc is usually considered to require repair. **CalTool for molbloc** software is available for facilities requiring the capability to adjust molblocs to agree with their mass flow standard.

1.1.3 HOW CALTOOL FOR molbloc WORKS

CalTool for molbloc supports the adjustment of certain proprietary molbloc coefficients to fit the molbloc mass flow measurements to a mass flow standard for a specific gas at a specific molbloc operating pressure.

The proprietary molbloc calibration coefficients manipulated by **CalTool for molbloc** are designated $C_{G(Re=0)}$ and β (beta). $C_{G(Re=0)}$ is the value of C_G extrapolated to a Reynolds number of zero (i.e., null flow) and β is the slope of the variation of C_G with Reynolds number.

CalTool for molbloc does not adjust molbloc calibration coefficients relating to compensation for changes in operating pressure. Therefore, adjustments made to a molbloc using **CalTool for molbloc** must be made using data collected at a single, stable upstream or downstream molbloc pressure and, following the calibration, the molbloc must always be used at the upstream or downstream pressure at which it was calibrated. This is the equivalent of a "single P calibration" (see molbox Operation and Maintenance Manual).

CalTool for molbloc makes separate gas specific adjustments for each gas that is flowed. Therefore, individual calibrations and molbloc adjustments must be made for each desired gas. **CalTool for molbloc** can be used to add gas calibrations for a molbloc. Added gas calibrations, like all molbloc calibrations using **CalTool for molbloc**, are only valid at the upstream or downstream pressure at which the molbloc is calibrated. This is the equivalent of a "single P calibration" (see molbox Operation and Maintenance Manual).

CalTool for molbloc includes all the tools necessary to run comparisons between molblocs and a mass flow standard, acquire data from the comparison, calculate new calibration coefficients and write the coefficients to the molbloc. It also includes tools to enter test data manually, edit test data, view calibration results, change the molbloc calibration date and create and load molbloc restore files.

As with any calibration, the results of a molbloc calibration are only as good as the mass flow standard used as a reference and the integrity of the calibration comparison process.

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NOTES

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2. GETTING STARTED

This section explains how to install **CalTool for molbloc** on your computer and provides an overview of the startup procedures.

2.1 SYSTEM REQUIREMENTS

CalTool for molbloc requires a minimum PC configuration and a molbox1 or molbox RFM for data collection and communication with the molbloc.

If your PC does not meet these minimum requirements, the software will not run as designed.

- Windows 95, 98 or NT
- 75 MHz Pentium
- 8 Mbytes of Ram
- 7 Mbytes of free hard disk space
- At least one available RS232 port and/or National Instruments Corporation IEEE-488 interface card

2.2 INSTALLING CALTOOL FOR molbloc

2.2.1 WINDOWS 95, 98, NT

❶ Start Windows operating system.

❷ Insert the **CalTool for molbloc** CD into your CD drive.

❸ The **CalTool** setup program will automatically run.

❹ If it does not, press the Start button, then select Run. In the Run dialog box, type D:\disk1\setup.exe, depending on label of the CD drive you placed the installation disk.

❺ The setup program will step through the installation process prompting you for entry of the necessary information.

❻ To run **CalTool for molbloc** press the Start Button, select Programs, then select **CalTool for molbloc** and click on the **CalTool** icon.

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2.2.2 RUNNING THE PROGRAM

Before running **CalTool**, establish a remote connection between a molbox1 or molbox RFM and the host PC. Do this by connecting your PC to the molbox using a standard RS232 cable and connecting one of the PC's communications ports to the molbox's Com1 port.

National Instruments Corporation IEEE-488 cards are also supported by **CalTool** for remote communication using the molbox's IEEE-488 interface. IEEE-488 users should connect a IEEE-488 cable to the IEEE-488 port on the molbox and to the desired IEEE-488 card in the host PC.

See the **molbox Operation and Maintenance Manual**, Remote Section, for additional information on molbox communication interfaces and settings.

Once you have set up the interface between the molbox and the PC, you are ready to run **CalTool**. Click the **CalTool** Icon in the **CalTool** program group in the Start menu.

When **CalTool** for molbloc loads, it assumes the communication settings that were in use when the program was last run. All program options that require a remote interface with a molbox use these settings. See Section 4.2.1 to change **CalTool** interface setups.

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3. NORMAL OPERATING PROCEDURES

3.1 TYPICAL START TO FINISH CALIBRATION PROCEDURE

The typical start to finish calibration procedure includes:

❶ Setting up to run the calibration (see Section 3.1.1).

❷ Running the calibration (see Section 3.1.2).

❸ Calculating and evaluating calibration results (see Section 3.1.2).

❹ Writing new calibration coefficients to the molbloc see Section 3.1.2).

❺ Verifying calibration results (if desired) (see Section 4.1.2).

❻ Creating the molbloc restore file (see Section 3.3).

A separate calibration is required for each gas with which the molbloc is to be used.

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3.1.1 SETTING UP TO RUN A CALIBRATION

> ⚠ Prior to calibrating a molbloc for the first time, a restore file of the existing molbloc should be created if one is not available. The restore file will allow the molbloc to be restored to its as received state should you wish to reverse the calibration process.

To set up and prepare the molbloc for calibration:

❶ Connect the molbloc to a calibrated molbox following the instructions in the molbox Operation and Maintenance Manual. The molbox must be properly calibrated for the molbloc calibration to be valid.

❷ Connect the molbloc to be calibrated in series with the mass flow standard that is serving as the reference. The molbloc must be installed so that the upstream or downstream pressure will be stable throughout the calibration. The fixed upstream or downstream pressure must be the same pressure at which the molbloc will be used in normal operation. If the molbloc is normally used in a molstic, calibrate the molbloc mounted in the molstic with the molstic pressure regulator at its normal setting. **CalTool for molbloc** adjustments are only valid for the operating pressure at which the calibration comparison is performed.

❸ Install a means to set a stable flow rate over the range of the molbloc. This could be a manual needle valve, a mass flow controller or a component of the mass flow standard. If the molbloc is normally used at an elevated static pressure with a constant upstream pressure, the flow control element is usually placed downstream of the molbloc. If the molbloc is used downstream with atmospheric or near atmospheric downstream pressure, the flow control device is usually placed upstream of the molbloc.

❹ Install a valve to shut-off the flow upstream of the molbloc and the reference mass flow standard.

❺ Connect a supply of the gas to be calibrated. Generally, gases with purity of 99.99 % or better should be used to achieve normal molbloc specifications.

3.1.2 RUNNING A CALIBRATION

Running the molbloc calibration consists of comparing the measurements of molbloc/molbox and the mass flow standard used as a reference at various flows within the molbloc range and logging data at each flow point. To run the molbloc calibration:

❶ Purge the complete system to clear the old gas with the new gas. The gas flowing through the molbloc and the mass flow reference must be pure when running the calibration. To purge the molbox, use the molbox purge function (if the molbox does not have the purge function, cycle the molbox pressure with the new gas repeatedly; consider downloading new molbox software from www.dhinstruments.com/software).

❷ Verify that the molbloc upstream or downstream pressure when flowing is the molbloc's normal operating pressure. This pressure must remain stable and constant throughout the calibration process. Press **[P&T]** on the molbox keypad to view the molbloc upstream and downstream pressures. If the molbox is in remote mode (remote LED lit), press **[ESCAPE]** on the molbox keypad to return to local mode so front panel is active.

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❸ Connect the calibration gas supply. Generally, gases with purity of 99.99 % or better should be used to achieve normal molbloc specifications. The calibration gas must be the gas for which the molbloc is to be calibrated, no surrogates or "k factors" are possible.

❹ Set the molbox measurement parameters:

ⓐ Press **[UNIT]** on the molbox keypad to set the desired mass flow unit of measure. Assure that the molbox mass flow unit and the mass flow reference standard mass flow unit are identical including the reference conditions in the case of volumetrically based mass flow units.

ⓑ Press **[SETUP]**, **<5stab>** on the molbox keypad to set the molbox stability criterion (ready/not ready indication). **CalTool for molbloc** uses the molbox ready/not ready indication to indicate when to take readings. The stability setting is typically set to ± 0.005 % FS/s of the molbloc or less. Note that the molbloc full scale flow depends on the molbloc size (range), the calibration gas and the calibration operating pressure. See Section 6 to determine the molbloc flow range for the calibration gas and pressure.

❺ Select the calibration test gas in **CalTool** using **[Setup]**, **[Test Gas]**. The test gas must be the gas for which the molbloc is to be calibrated, no surrogates or "k factors" are possible.

❻ Enter the **CalTool** Calibration Test function using **[Calibration]**, **[Calibration Test]**. **CalTool** establishes communications with the molbox with which the PC is interfaced and reads the molbloc characteristics off the molbloc EEPROM. If **CalTool** cannot communicate with the molbox, or if the molbox is not connected to a valid molbloc, an error message is displayed. After reading the molbloc information, the **<Reference Information>** window is displayed.

❼ Enter information to identify the mass flow standard being used as a reference in the calibration. This information will be included in the test data file.

After entry of the reference information, the **<Test Pressure>** window is displayed. Enter the value of molbloc upstream or downstream pressure that will be held constant through the test.

After entry of the test pressure, the **<Run Screen>** and **<Test Data Entry>** windows are displayed (see Section 4.1.1.1).

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❽ Run the test flow points and log the data at each point. The recommended test points are 10, 25, 50, 75, 100 % FS of the molbloc range for the calibration pressure and gas. The minimum number of points for **CalTool** to calculate calibration coefficients is three. The procedure for each test point is:

ⓐ Use the flow setting device to set the flow to the desired flow increment and allow the flow to stabilize until the ready/not ready indicator on the **CalTool** run test screen indicates green. For certain reference flow standards, particularly those that are based on a fixed measurement cycle, this may require a bypass valve to flow by the standard.

ⓑ Tare the molbox by clicking on the **[Tare]** icon on the Run Test Toolbar (see Section 4.1.1.2).

ⓒ Adjust the **[Avg Time]** on the Run Test Toolbar if desired. This setting determines the amount of time over which molbox readings will be averaged when the data point is recorded. When the reference mass flow standard is based on a fixed measurement cycle, it is important that the **CalTool** averaging time and the standard's measurement cycle be synchronized.

ⓓ When ready to take the flow data point click the **[Take Point]** icon on the Run Test Toolbar or press ENTER on the PC. The **<Run Screen>** displays **<AVERAGING>** while the averaging time counts down and the molbox average flow reading is logged. Press ESC on the PC or click the **[Abort Point]** icon to abort a point while averaging.

ⓔ The **<Reference Flow>** window is displayed. Enter the average reference flow observed over the same period as that over which the molbox flow was averaged. When a second molbloc/molbox is used as the reference, **CalTool** automatically averages and logs the reference flow.

ⓕ Observe the results of the point in the **<Test Data Entry>** grid. If you would like to repeat the point, click once on the **[Repeat Test Point]** icon on the Run Test Toolbar. Each click moves back one point.

ⓖ Repeat Step (8) for each of the test points of the test.

❾ End the test run by clicking the **[End Test]** icon on the Run Test Toolbar. The **<Save Data File As>** window is displayed.

❿ Save the test data file as is or modify the name and/or path. The **<Calculation/Activation>** window is displayed.

⓫ Observe and evaluate the calibration results in the **<Calculation/Activation>** window. These include the new molbloc calibration coefficients for the calibration gas and the predicted as left data. **CalTool** determines the as left values by recalculating the molbloc measured flow using the new molbloc calibration coefficients.

⓬ If the calibration results are acceptable, activate the new calibration coefficients. To activate the new calibration coefficients, click **[Activate Calibration]**. This causes the new calibration coefficients **for the calibration gas used in the test** to be written to the molbloc EEPROM. If you do not want to activate the new calibration coefficients, click the **<Calculation/Activation>** window's close control box or go directly to any other **CalTool** menu option.

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⓭ If desired, verify the calibration as left data by rerunning the test. To verify, rerun the test following Steps (6) through (9) but; in Step (6) use **[Calibration]**, **[Verification Test]** (see Section 4.1.2). A verification test ends without going to the calculate and activate calibration options. If desired, Verification Test data files can still be used to generate new calibration coefficients by using the **[Calibration], [Calculate]** option (see Section 4.1.3).

⓮ Repeat Steps (1) through (13) for each calibration gas that is to be included on the molbloc. Consider changing the molbloc calibration date (see Section 4.4.5).

⓯ Create a molbloc restore file using **[Tools]**, **[Create Restore File]**. The molbloc restore file provides a backup record of all the information on the molbloc's EEPROM so that, should the EEPROM become corrupted or damaged, its content can be restored (see Section 3.3).

3.1.3 USING A molbloc/molbox AS THE REFERENCE MASS FLOW STANDARD

In some cases, the reference mass flow standard used in a molbloc calibration may be another molbloc/molbox system. In this case, readings from the reference can be taken automatically and the test and reference molbox readings are automatically synchronized.

To set up for automatic data acquisition from a molbox as the reference mass flow standard, set up the reference molbox interface using **[Setup]**, **[Interface]**. If the reference interface is other than **<None>**, **CalTool** will always try to communicate via the interface when a test is run. To return to manual entry of reference flow values, set **[Setup]**, **[Interface]**, **[Reference]** to **<None>** (see Section 4.2.1).

3.1.4 PRECAUTIONS TO ASSURE GOOD MEASUREMENTS

To help minimize additional uncertainties in the comparison between the test molbloc/molbox and the mass flow standard used as a reference, consider the following:

- Assure that there are NO leaks in the system. Leaks cause the flow through the molbloc and the reference to be different making a valid comparison of the two impossible.
- Verify that the flow unit of measure for the molbloc and the mass flow standard are identical. Consider the reference temperature on volumetrically based units of mass flow.
- Verify that the calibration gas setup in **CalTool**, the gas expected by the reference mass flow standard and the gas actually flowing are the same.
- Be sure to calibrate the molbloc for the correct range for the gas and operating pressure. Look the range up in the range charts in Section 6.
- Set the test molbox stability criterion to an acceptable value for the pressure dependent flow range. Typically 0.005 % FS/s is used.
- Use a molbox that is known to have a valid calibration. If the molbox pressure transducer's measurement uncertainty is not in tolerance, the molbloc calibration will not be valid.
- Check that the molbox **[K]** is set to zero.

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- Check that the molbox **[SETUP]**, **<6adj>** Adder = 0 and Multiplier = 1.
- Assure that the molbloc upstream or downstream pressure is properly set and held constant throughout the calibration.
- Tare the molbox at the beginning of the test and preferably, just before taking data at each test point.
- Be sure to fully purge the complete test system of one gas when using a new gas so that the gas flow when making measurements is composed 100 % of the expected gas.
- Assure that the molbloc and reference standard mass flow measurements are synchronized. If the flow standard operates on a fixed measurement cycle (as is the case with standards based on rate of volume or pressure change), the averaging time of the standard and the molbloc must coincide precisely.
- Set the reference mass flow standard to measure the gas that is flowing. Do not attempt to use gas conversion or "K" factors.
- Verify the repeatability of your measurement system. Run an identical Verification Test three times under conditions that are as constant as possible. Evaluate the evolution in the disagreements between the molbloc and the reference mass flow standard from test to test to quantify the repeatability of the system. As a general rule, the system repeatability should be 5 to 10 times better than the target measurement uncertainty for the molbloc.

3.2 MANUAL CREATION OF A CALIBRATION DATA FILE

To calculate new molbloc calibration coefficients and as left data, **CalTool for molbloc** uses as received molbloc calibration coefficients and data contained in a *.dat file. The *.dat file is created automatically by a Calibration or Verification Test run by **CalTool**.

Running a Calibration or Verification Test requires a live interface connection to a molbox.

If a molbox is not available to run a Calibration or Verification Test, a data file (*.dat) can be created manually. This feature allows **CalTool for molbloc** to calculate calibration coefficients and as left data using existing test data that was not recorded by **CalTool** or if an interface with the molbox cannot be established. A valid interface with a molbox connected to the molbloc being calibrated is always required to calculate new calibration coefficients and/or to activate new coefficients to the molbloc.

Use **[Data]**, **[Create]** to create a calibration date file (*.dat) manually (see Section 4.3.1).

A valid data file must include the Reynolds number of the molbloc flow for every flow point. When taking calibration test data manually to be entered later into CalTool, be sure to record the Reynolds number of the molbloc flow at each point.

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3.3 CREATING AND USING molbloc RESTORE FILES

Every molbloc is equipped with an EEPROM in which its specific identification and calibration information is stored. The complete molbloc EEPROM contents can be saved in restore files (*.brs). The restore files can be used to reload the molbloc information if the molbloc EEPROM is accidentally altered or corrupted.

DHI maintains restore files on every molbloc it delivers new or on which it performs a recalibration. These restore files and a file loading utility can be provided to molbloc users to recover their molbloc data. However, if molbloc calibration coefficients have been altered using **CalTool**, the restore files maintained by **DHI** are no longer current. **CalTool** includes a tool to create restore files and load them onto molblocs so that **CalTool** users can maintain their own restore files.

It is recommended that a molbloc restore file (*.brs) be created and archived every time a molbloc is calibrated and verified using **CalTool**.

To create and/or load molbloc restore files use **[Tools]**, **[Create Restore File]** and **[Restore molbloc]** (see Sections 4.4.3, 4.4.2).

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NOTES

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4. MAIN MENU OPTIONS

4.1 [CALIBRATION] MENU

The **[Calibration]** menu offers selections to run tests and calculate as left molbloc coefficients and data from a data file. The **[Calibration]** menu includes the following selections: **[Calibration Test]**, **[Verification Test]**, **[Calculation]** and **[Exit]**.

4.1.1 [CALIBRATION TEST]

[Calibration Test] is used to run a comparison of a molbloc and a mass flow standard. The test ends in the calculation of new calibration coefficients and as left calibration data. The Calibration Test automatically acquires data from the molbloc/molbox at each flow point of the test and logs it to a data file (*.dat).

For a Calibration Test to run, **CalTool** must be able to establish remote communications with a molbox to which a molbloc is connected. Use **[Setup]**, **[Interface]**, **<Test molbox>** (see Section 4.2.1) to set up communications with the test molbox.

In a Calibration Test, the readings of the reference mass flow standard are entered manually or can acquired automatically if the reference mass flow standard is a molbox. Use **[Setup]**, **[Interface]**, **<Reference>** (see Section 4.2.1) to set up communications with the reference molbox. For manual reference mass flow entries standard **[Setup]**, **[Interface]**, **<Reference>** must be set to **<None>**.

The test gas (the gas for which the molbloc is being calibrated and that will be flowed when running the calibration test) must be selected prior to running the Calibration Test. Use **[Setup]**, **[Test Gas]** to select the test gas (see Section 4.2.2).

A major benefit of using the Calibration Test option is that CalTool writes the molbloc as received calibration coefficients in the data file. This information is verified prior to activating new coefficients to help ensure the validity of the calibration.

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Running a Calibration Test

When **[Calibration Test]** is selected, **CalTool** attempts to establish communications with the test molbox, read the coefficients of the molbloc attached to the molbox and set the molbox for the test gas. If communications with a test molbox cannot be established, a Calibration Test cannot be run and an error message is displayed. If communication with a test molbox is not possible, consider creating a test file manually using **[Data]**, **[Create]** (see Section 4.3.1).

Once communication with a test molbox (and a reference molbox if present) has been established, **CalTool** prompts the operator to identify the reference mass flow standard. The labels entered here will be stored in the Calibration Test data file (*.dat) for future reference identification.

Following entry of the reference identification, **CalTool** prompts the operator for entry of the fixed upstream or downstream test pressure at which the molbloc is being calibrated. The pressure value and pressure unit should be entered. These will be stored in the Calibration Test data file (*.dat). This information is important since the calibration performed by **CalTool** is valid only at the test pressure.

Following entry of the test pressure, the **<Run Screen>** is presented (see Section 4.1.1.1). It's current status is **<RUNNING>** and it actively reads and displays a variety of molbloc measurements.

The Run Test Tool Bar (see Section 4.1.1.2) is used to interact with the **<CalTool Run Screen>**.

Once a flow point has been set and stabilized (ready/not ready indicator green), click the **<Take Point>** icon or press ENTER on the PC to log the point. This causes **CalTool** to read the molbox for the averaging time. The reading can be interrupted by clicking the **<Abort Point>** icon or by pressing ESC on the PC. The molbox can be tared prior to taking the point by clicking the **<Tare molbox>** icon (see Section 4.1.1.2).

After **CalTool** has logged the averaged molbox reading, the user is prompted to enter the reference mass flow standard reading. Do not include the unit of measure when entering the reference mass flow reading.

Following entry of the reference mass flow reading, **CalTool** fills in the **<Test Data Entry>** window's data grid with the information for the point just taken and returns to the **<RUNNING>** status. Test points can be repeated by clicking the **<Repeat Test Point>** icon. Each click moves back one point, and all points forward must then be retaken.

A maximum of 22 and a minimum of 3 data points may be included in a Calibration Test. For best results, the points should be distributed across the flow range. The recommended distribution is 10, 25, 50, 75, 100 % FS. The molbloc range depends on the molbloc size, the test pressure and the calibration gas. See Section 6 for molbloc gas and pressure dependent range tables.

The test may be aborted at any time, without creating a data file, by clicking the **<Abort Test>** icon.

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For a normal test ending which creates a data file, click the **<End Test>** icon. After confirming that the test should be ended, the **<Save Data File As>** window is presented. Edit the name and/or path of the data file as desired and click **<Save>**.

When running a Calibration Test, after the data file has been saved, **CalTool** goes directly to the **<Calculation/Activation>** window (see Section 4.1.3).

4.1.1.1 CALIBRATION TEST/VERIFICATION TEST RUN SCREEN

The run screen is active when a Calibration Test or Verification Test is running.

The screen can be scaled by dragging its corners or positioned by dragging its title bar at any time while a test is running.

The run screen provides a convenient display of the test molbloc flow conditions (Reynolds number, upstream pressure, downstream pressure, average temperature) as well as the current program status.

The round red/green indicator in the upper left hand corner is the ready/not ready indicator. The indicator is green when the test molbloc/molbox flow becomes ready by meeting the molbox stability criterion (see the molbox Operation and Maintenance Manual, ready/not ready section).

The blue status panel tracks the current test point and averaging information. The **<Current>** display indicates the point number, within the overall test, of the point that is being taken or that will be taken when the Take Point icon is clicked. The **<Avg Time>** display indicates the molbox averaging time for a point. The time counts down to zero when **CalTool** is taking a point. The bottom line of the panel indicates the current program status: **<IDLE>** when a test is NOT running; **<RUNNING>** when a test is running but a point is NOT being taken; **<AVERAGING>** while counting down the averaging period when taking a point; **<DATA ENTRY>** when the user must make an entry; **<TARE MODE>** when the **CalTool** tare screen is active and the user has the ability to tare the test or reference molbox.

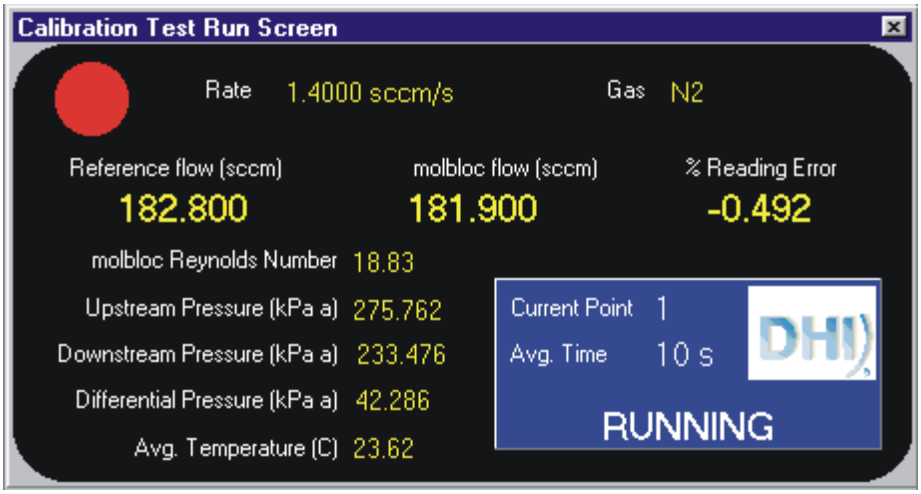

Figure 2. Calibration Test/Verification Test Run Screen

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4.1.1.2 RUN TEST TOOLBAR

The Run Test Toolbar is used to control a test. The Toolbar is active when a Calibration or Verification Test is running. Clicking the Run Test Toolbar icons executes various test functions. The Run Test Toolbar icons include: Take Point, Abort Current Point, Repeat Test Point, Display Graph, End Test, Abort Test, Average Time, Tare.

Table 1. Tools Available on the Run Test Toolbar

ICON	DESCRIPTION
Take Point	Starts the Take Point sequence to take a test point in a Calibration or Verification Test. The Take Point sequence includes: start molbox reading averaging cycle and average over time period, log average molbox reading to data file, acquire reference mass flow standard reading by manual entry or automatically. Pressing the ENTER on the PC key as a shortcut to this function. The averaging time is determined by the **<Avg Time>** field on the toolbar.
Abort Point	Interrupts the Take Point process and aborts the current point. Press ESC on the PC as a shortcut to this feature.
Repeat Point	Used to retake a test point. Decrements the current point back once each time it is clicked. If clicked several times to go back more than one point, all the points must be retaken. The **<Repeat Point>** icon is not active while taking a point.
Tare molbox	Starts the Tare molbox sequence to tare the test or reference molbox. After selecting which molbox to tare and whether to tare on the upstream or downstream molbloc port, the **<Tare molbox>** window displays. Pressing the **<Tare>** button causes the molbox to execute the tare function and activate the new tare(s). If an invalid tare occurs, repeat the process. When taring is complete, use the close control box in the top right hand corner to close the tare display and return to the **<Run Screen>**. See the molbox Operation and Maintenance Manual for complete information on taring and its importance to good measurements. The **<Tare molbox>** icon is not active while taking a point.
Display Graph	Cause the **<Plots>** window to be displayed with a real time % of reading error plot of the test that is running.
End Test	Used for a normal test ending after execution of the last data point. After confirmation, causes the **<Save Data File As>** window to be presented. Accept the default data file name and path or edit and select **<Save>** to save the data file. If the test was a Calibration Test, operation proceeds to the **<Calculation/Activation>** screen.

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Table 1. Tools Available on the Run Test Toolbar (Continued)

ICON	DESCRIPTION
Abort Test	Used to completely abort a Calibration or Verification Test without saving data. After confirmation, causes test execution to stop and status to go to **<IDLE>**.
Avg Time **(Text Entry)**	Enter the time in seconds over which molbox readings are to be averaged. The minimum averaging time is 5 seconds and the maximum is 9999 seconds. The averaging time setting affects both the test and reference molbox if the reference mass flow standard is a molbox. The averaging time can be edited between points while a test is running.

4.1.2 [VERIFICATION TEST]

[Verification Test] is used to run a simple comparison of a test molbloc and a reference standard that does not end in calculation and activation of new molbloc calibration coefficients.

A Verification Test is identical to a Calibration Test in both setup and operation (see Section 4.1.1) but the Verification Test does not go directly to Calculation/Activation; the test ends with a display message of the maximum % Reading error and the default name of the resulting data file is *(Verify)*.dat. Calibration Test and Verification Test data files are identical in structure. A Verification Test data file can be used with the Calculation function to determine new molbloc calibration coefficients and predict as left data if desired (see Section 4.1.3).

The Verification Test is normally used after a calibration to verify the predicted as left data. It is also used for routine comparisons of molblocs and a reference standard.

4.1.3 [CALCULATION]

[Calculation] is used to calculate new molbloc coefficients and predicted as left data from a data file (*.dat), for example a data file that has been created or edited manually or a Verification Test data file. This function also allows the results of the calculation to be activated by writing to the molbloc and creating a result file (*.res).

When **[Calculation]** is selected, the file on which calculations are to be performed must be specified. The **<Select Data File>** window is presented. Select the desired data file.

The Calculation function requires that valid communications with a molbox be set up and that the molbloc identified in the *.dat file selected is connected to the molbox. If the information in the data file, including the as received molbloc calibration coefficients for the gas specified in the data file, does not match the molbloc that is connected, the calculate process is aborted. This feature is to assure that calculations are being performed for the correct molbloc with the correct calibration coefficients. If the molbloc coefficients are not the coefficients that were active when the data in the data file was taken, the calculation of the new calibration coefficients and as left data would not be valid.

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If the information contained in the selected data file matches the current molbloc, **CalTool** opens the **<Calculation/Activation>** screen and calculates new (as left) molbloc calibration coefficients for the test gas and predicted as left data. The as left data is the as received data recalculated using the new molbloc calibration coefficients. At this point, no changes have been made to the molbloc. To make changes to the molbloc, **<Activate Calibration>** must be selected.

Click **<Activate Calibration>** to cause the new (as left) calibration coefficients for the test gas to be written to the molbloc. **CalTool** will again verify the actual molbloc information with the information stored in the data file. If these do not match, the calibration cannot be activated. If they do match, the new calibration coefficients are written to the molbloc and the **<Save Result File As>** window is presented. Only the calibration coefficients relating to the gas specified in the *.dat file are adjusted, no other molbloc information is adjusted.

<Calculate> is available to cause **CalTool** to recalculate, for example if an error occurred during the original calculation.

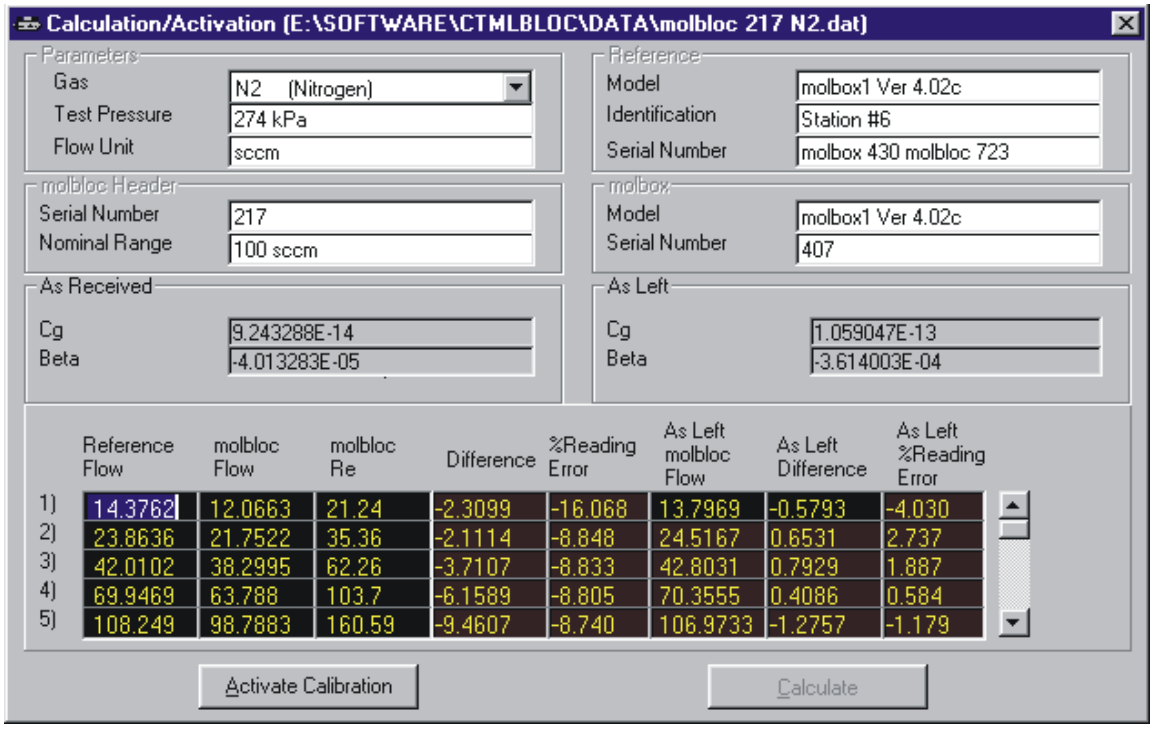

Figure 3. Calculation/Activation Screen

4.1.4 [EXIT]

[Exit] is used to close the **CalTool** program.

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4.2 [SETUP] MENU

The **[Setup]** menu offers selections to set up communications interfaces with the test and the reference and to select the test gas with which tests are run. The **[Setup]** menu includes the following selections: **[Interface]** and **[Test Gas]**.

4.2.1 [INTERFACE]

[Interface] is used to set up the interface with the test molbox and the reference mass flow standard. Many **CalTool** functions require a valid interface with a test molbox.

To set up **CalTool** communication interfaces, select **[Setup]**, **[Interface]**. The **<Interface Setup>** window is presented. In the **<Device>** selection box, select **<Test molbox>** to set up the interface to the test molbox or **<Reference>** to set up the interface to the reference.

The current interface for the selected device is displayed in the **<Remote Interface>** box. The drop down list includes the three interface choices that **CalTool** supports: **<RS232>**, <**IEEE-488>** and **<None>**. **<None>** is only available for reference since a remote interface with a test molbox is required. **<RS232>**, <**IEEE-488>** are apply for the reference only if the reference is a molbox. **CalTool** does not support remote communications with references other than a molbox.

If **<RS232>** is selected, the com port and port settings can be changed by clicking any of the RS232 settings fields and making the desired selections on the RS232 setup form. Default molbox COM1 settings are 2400, E, 7, 1.

If **<IEEE-488>** is selected, the IEEE-488 address of the molbox must be specified in the field provided. The IEEE-488 Card in the PC must be selected in drop down list in the **<IEEE-488>** selection box at the bottom of the form. The IEEE-488 card must be set up with default addresses and 32 bit drivers for a Windows based 32 bit operating systems.

After a device interface is modified, click **<Accept>** so the value is updated in memory. If **<Accept>** is not clicked, the interface value will not be saved.

<Communications Test> causes **CalTool** to send a test command to the molbox. The detection status will display after the command is sent.

Select **<Close>** to exit the interface setup form.

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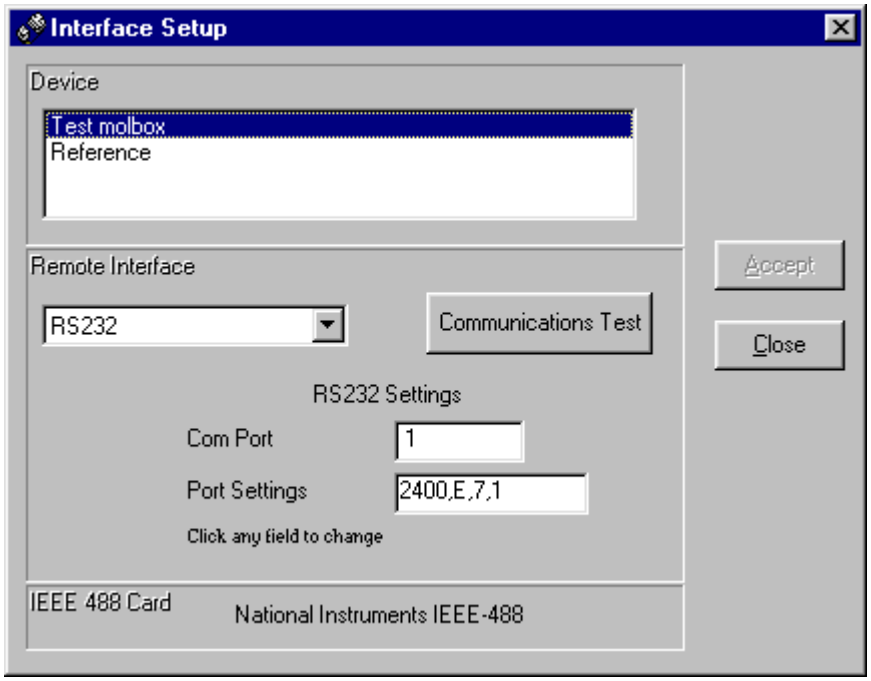

Figure 4. Interface Setup Window

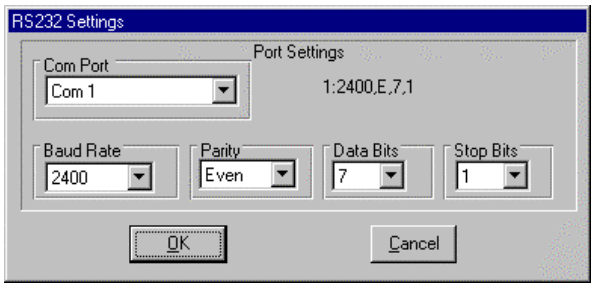

Figure 5. Interface Setup Window, RS232 Settings

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4.2.2 [TEST GAS]

[Test Gas] specifies the gas species for which **CalTool** Calibration and Verification Tests are run.

To select the test gas, select **[Setup]**, **[Test Gas]**. A drop down menu of the test gases available appears. The current test gas is checked. To change test gas, click the desired gas.

The test gas list available in CalTool is the complete list of molbox supported gases at the time the version of CalTool was released. If your version of CalTool does not include a test gas that is available on the molbox you are using or vice versa, visit www.dhinstruments.com to download a newer version of CalTool and/or molbox embedded software.

4.3 [DATA] MENU

The **[Data]** menu offers various tools to work with **CalTool** data files. The **[Data]** menu includes the following selections: **[Create]**, **[Edit]**, **[Plot]**, **[Print]** and **[View]**.

4.3.1 [CREATE]

[Create] is used to create a data file (*.dat) manually. This option is useful to create a data file from data taken at a time or place when **CalTool** with remote communications to a test molbox were not available.

To create a data file (*.dat) manually, select **[Data]**, **[Create]**. The **<Test Data Entry>** window is presented. Fill out the form.

The Test Gas may be selected from the **<Gas>** drop down list.

The molbloc serial number must be correct as it will be verified and must match the connected molbloc when the data file is used with the Calculate function (see Section 4.1.3).

In the test data grid, **the reference flow, molbloc flow and molbloc Reynolds number must** be entered for a minimum of three points. **CalTool** automatically calculates the difference and % reading error. 0 should not be included as a reference flow point as this results in an invalid % reading error.

Select **[Save]** to save the data file. **CalTool** checks for invalid or missing data. Once valid data has been entered into all required fields, the **<Save Data File As>** window is presented. Accept the default file name and path or edit as desired.

Use **[Clear]** to erase all data from the entry form. This is useful when creating multiple data files to get a clean form after each save without re-selecting the **[Data], [Create]** option.

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Manual data files do not contain the as received molbloc calibration coefficients so CalTool cannot verify them prior to activating a calibration. For this reason, when using manually created data files to activate a calibration, it is critical to assure that the molbloc has the same calibration coefficients during calibration calculation and activation as it did during the actual data gathering process. Failure to assure consistency is likely to result in invalid calibrations since CalTool will be using incorrect data in its calculations.

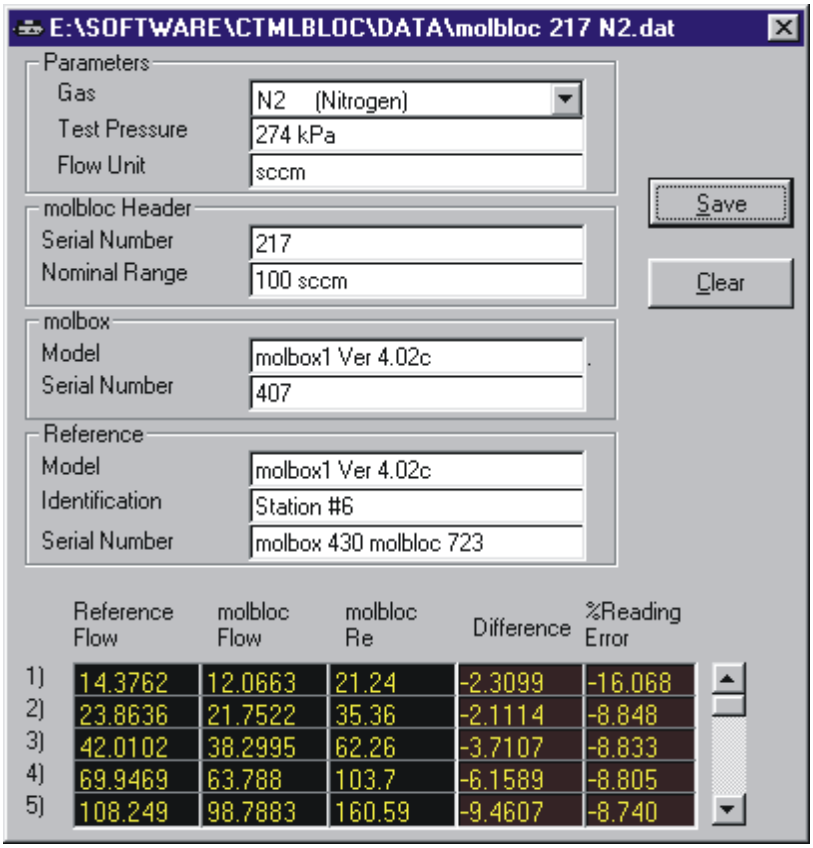

Figure 6. Test Data Entry Form

4.3.2 [EDIT]

Use **[Data]**, **[Edit]** to edit an existing data file (*.dat).

The operation of **[Edit]** is identical to **[Create]** except that an existing data file is selected and loaded into the editor instead of starting from a blank form (see Section 4.3.1).

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4.3.3 [PLOT]

[Plot] allows the **CalTool** % of reading error plot for an existing data (*.dat) or result (*.res) file to be viewed.

To view a plot select **[Data]**, **[Plot]**. Then click **<Result File>** or **<Data File>** to specify the type of file to be plotted. The **<Select File>** window is presented. Select the desired file and click **<Open>**.

The plot can be printed using **[Data]**, **[Print]** or the **<Print>** toolbar option (see Section 4.3.4).

% of reading error is calculated following ((test-reference)/reference*100).

Plots of result files (*.res) include both the as received and as left data % of reading error plots.

4.3.4 [PRINT]

[Print] allows a data file (*.dat), result file (*.res), plot or other text displays to be printed to the selected Windows printer.

To print, select **[Data]**, **[Print]**. Then click the desired item to be printed from the drop down list. If **<Result File>** or **<Data File>** is selected, the file to print must be selected from a **<Select File>** window.

[Data], **[Print]**, **<Current Text Display>** prints the contents of any open test display, for example a formatted result file or a molbloc calibration record. This function is useful for maintaining hard copy records of **CalTool** information. The toolbar print option on the text viewer is a shortcut to this function.

4.3.5 [VIEW]

[View] allows result (*.res) and data (*.dat) files to be viewed within **CalTool**.

After selecting **[Data]**, **[View]** select **<Result File>** or **<Data File>** to view the unformatted, comma delimited file. Select **<Formatted Result File>** or **<Formatted Data File>** to view a file in a report style format that is more readable than the standard comma delimited format. A print option on the viewer can be used to print the text display.

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4.4 [TOOLS] MENU

The **[Tools]** menu offers various tools to support the calibration and adjustment of molblocs with **CalTool**. The **[Tools]** menu includes the following selections: **[Remove Gas Calibration]**, **[Restore molbloc]**, **[Create Restore File]** , **[View molbloc Calibration]** and **[Change molbloc Calibration Date]**.

4.4.1 [REMOVE GAS CALIBRATION]

[Remove Gas Calibration] allows undesired gas calibrations to be removed individually from a molbloc.

To remove the calibration of a gas from a molbloc, select **[Tools]**, **[Remove Gas Calibration]**. **CalTool** reads the contents of the connected molbloc through the test molbox. If remote communication with a test molbox cannot be established, an error message displays. The **<Remove Gas>** window is displayed including a listing of all the gases (except N2) for which there are calibration coefficients on the connected molbloc. Click the checkbox next to the gas or gases to be removed. Then click **<Remove Gas>**. After confirmation, the calibration for the selected gas is removed from the molbloc.

The nitrogen (N2) gas calibration cannot be removed from a molbloc.

Select **[Exit]** to close the **<Remove Gas>** window.

Removing a gas from a molbloc is not a reversible process. To restore the gas a new calibration will have to be run, a restore file will have to be loaded for the molbloc.

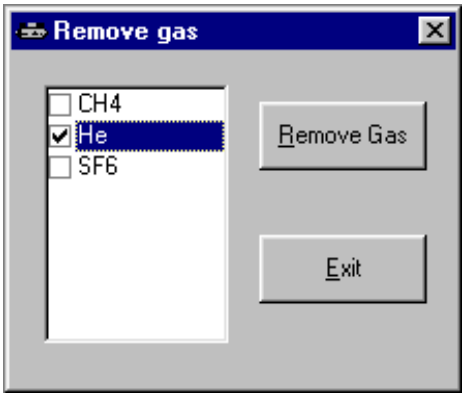

Figure 7. Remove Gas Window

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4.4.2 [RESTORE molbloc]

Restore changes the complete molbloc EEPROM file including header information and all gas calibrations. Restore molbloc does not work on gases individually, it works with the complete restore file which contains ALL molbloc data.

[Restore molbloc] is used to restore a molbloc whose EEPROM has been corrupted or to return a molbloc to a previous state. Using restore molbloc requires a valid restore file (*.brs). Restore files are created using **[Create restore file]** (see Section 4.4.3). **DHI** technical service maintains restore files for molblocs. However, these restore files will return the molbloc to the calibration state last set by **DHI**. Any subsequent calibrations performed with **CalTool** are be updated. For this reason it is important to create restore files when multiple calibrations have been performed (see Section 3.3).

To load a restore file (*.brs) onto a molbloc, select **[Tools]**, **[Restore molbloc]**. The **<Select molbloc Restore File>** window is presented. Select the desired restore file (*.brs) and select **<Open>**. **CalTool** requires several confirmations that the molbloc should really be restored with the identified restore file.

Following the restore operation, **[View molbloc Calibration]** can be used to view the information on the molbloc.

The Restore option should only be used when absolutely necessary. Systematic restoring of the molbloc is not recommended.

4.4.3 [CREATE RESTORE FILE]

[Create Restore File] is used to create a molbloc restore file (*.brs). A molbloc restore file is a copy of the complete molbloc EEPROM contents that can be downloaded to the molbloc EEPROM using **[Restore molbloc]** (see Section 4.4.2).

To create a molbloc restore file (*.brs), select **[Tools]**, **[Create Restore File]**. After **CalTool** reads the molbloc contents through the test molbox, the **<Save molbloc Restore File As>** window is presented. Accept file name and path or edit it if desired. Then select **[Save]** to create the restore file.

If any errors occur while a restore file is being created, make sure the file is deleted and retry. Creating a restore file does not modify any of the molbloc EEPROM contents, it only saves them.

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4.4.4 [VIEW molbloc CALIBRATION]

[View molbloc Calibration] is used to view the current molbloc header information and gas **CalTool** accessible calibration coefficients for all the gases for which the molbloc has calibrations.

To view the calibration information of the molbloc that is connected to the test molbox, select **[Tools]**, **[View molbloc Calibration]**. After **CalTool** reads the molbloc EEPROM, the EEPROM information is displayed on the text display. The view option is a good check point for molblocs that have recently been restored (see Section 3.3) or to determine the gases for which a molbloc has calibrations.

4.4.5 [CHANGE molbloc CALIBRATION DATE]

[Change molbloc Calibration Date] is used to change the calibration date stored in the molbloc EEPROM. Since each molbloc has only one calibration date, **CalTool** does not automatically change the calibration date each time a new gas is added. It is up to the user to define the purpose and use of the molbloc calibration date. It is common practice to allow this date to always represent the last factory re-calibration or the last Nitrogen calibration. Nitrogen calibrations are significant because this calibration is used internally by the molbox when a gas not calibrated on a molbloc is used. Regardless of the method selected consistency is most important.

Select **[Tools]**, **[Change molbloc Calibration Date]** to read the molbloc and display the current calibration date. Edit the date as desired. When entering and viewing the date, the format must be YYYYMMDD where:

- YYYY: 4 digit year
- MM: 2 digit month
- DD: 2 digit day

January 23, 1999 must be entered and displays as 19990123. It is necessary to include a leading zero for month and day values that are less than 10 to insure the field always contains 8 characters. When the molbloc has an invalid date stored in the EEPROM, **CalTool** displays the default calibration date 19800101.

The molbloc calibration date displayed and changed by [Change molbloc Calibration Date] is included in the [View molbloc Calibration] feature, data files (*.dat) and result files (*.res).

4.5 [WINDOW] MENU

The **[Window]** menu allows selection of which window to place on top among all the windows currently open in **CalTool**. Each new window opened in **CalTool** automatically adds to the list of available selections.

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5. CALTOOL FILE TYPES AND CHARACTERISTICS

5.1 INTRODUCTION

CalTool for molbox creates and manipulates three different types of files which are detailed in Sections 5.2 through 5.4. These include:

- **Data Files (*.dat)**: Files into which **CalTool** logs information from Calibration and Verification Tests (see Section 4.1.1).
- **Result Files (*.res)**: File created from a data file after a calibration has been activated (see Section 4.1.3). Includes the as left data calculated from the as received data (results).
- **Restore Files (*.brs)**: Copies of the complete information contained in a molbloc EEPROM (see Section 3.3).

5.2 DATA FILE

Data files are the files created by **CalTool** to store the information from a Calibration or Verification Test.

The default data file name is "molbloc sn NNNN *(Verify)* GGGG.dat" where:

- molbloc sn: file label
- NNNN: the molbloc serial number
- *(Verify)*: label present only on files created by a Verification Test to distinguish them from a Calibration Test
- GGGG: the calibration gas used in the Calibration or Verification Test
- .dat: automatic file extension of a data file

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The default path for a data file is "CalTool for molbloc/Data/*.dat. If a new file location is selected while saving, all data (*.dat) files will be saved to the selected path by default until another path selection is made.

The data file is comma delimited for easy use in other applications. If a data file is created manually, the Calibration Date, CG and Beta values will be blank. In this case, it is critical that the molbloc have the same calibration coefficients during calibration activation as it did during the actual data gathering process. Failure to follow this step may result in large discrepancies between the predicted as left molbloc error and the actual as left error. If the manually created data file is used to activate a calibration, the current molbloc coefficients are automatically written to the data file.

In the sample data file, all fields that appear in italics are fixed fields created by **CalTool**. The calibration instruments and process determine the remaining information.

Sample data file:

```
molbloc SN, 1281
molbloc Range, 100.0 sccm
Cal Date, Cg, Beta
19991116 ,2.8248E-16,-3.918E-05
molbox Model, molbox1 Ver4.02c
molbox SN, 407
Test Gas, N2
Test Pressure, 274 kPaa, sccm
Reference SN, molbox 430 molbloc 723
Reference ID, Station #6
Reference Model, molbox1 Ver4.02c
Test Data
Ref Flow, molbloc Flow, molbloc Re, Diff, %Rdg Err
 14.3762, 13.0663, 21.24,-1.3099,-9.112
 23.8636, 21.7522, 35.36,-2.1114,-8.848
 42.0102, 38.2995, 62.26,-3.7107,-8.833
 69.9469, 63.788, 103.7,-6.1589,-8.805
 108.249, 98.7883, 160.59,-9.4607,-8.740
```

5.3 RESULT FILE

A result file is created by **CalTool** from a data file (see Section 5.2) and the results of the calculation function when a calibration is activated (see Section 4.1.3). The result file is identical to the data file but it contains additional information including the calculated as left molbloc calibration coefficients and as left test data for the test gas. The result file also has a different file extension (*.res).

The default result file name is "molbloc sn NNNN GGGG.res" where:

- molbloc sn: file label
- NNNN: the molbloc serial number
- GGGG: the calibration gas used in the Calibration or Verification Test from which the result file was created
- .res: automatic file extension of a result file

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If the result file is created from a *.dat file resulting from a Verification Test, (Verify) is NOT included in the *.res file name.

The default path for a result file is "CalTool for molbloc/Data/*.res. If a new file location is selected while saving, all result (*.res) files will be saved to the selected path by default until another path selection is made.

The result file is a comma delimited file for easy use in other applications. In the sample result file, all fields that appear in italics are fixed fields created by **CalTool**. The calibration instruments and process determine the remaining information.

Sample Result File:

```
Wed November 24, 1999
09:58 AM
Test Gas, Test Pressure, Flow Unit
N2,274 kPaa, sccm
Reference Model, Reference ID, Reference SN
molbox1 Ver4.02c,Station #6,molbox 430 molbloc 723
molbox Model, molbox SN
molbox1 Ver4.02c,407
molbloc SN, Nominal Range, Cal Mode
1281,100.0 sccm,Recalibration
As Received Calibration
Cal Date, Cg, Beta
19991116,3.104707E-16,-5.848963E-05
As Left Calibration
Activation Date, Cg, Beta
1991116,3.101733E-16,-4.422007E-05
Test Data
Ref. Flow, molbloc Flow, diff, %Rdg Err, As Left flow, As Left Diff, As
Left %Rdg Err
108.131,107.963,-0.168,-0.155,108.1305,-0.0005,0.000
78.7568,78.6797,-0.0771,-0.098,78.7478,-0.009,-0.011
61.9754,61.9475,-0.0279,-0.045,61.9771,0.0017,0.003
43.1317,43.141,0.0093,0.022,43.1428,0.0111,0.026
20.9995,21.0057,0.0062,0.030,20.996,-0.0035,-0.017
```

5.4 molbloc RESTORE FILE

Restore files are created by **CalTool** using **[Tools]**, **[Create Restore File]** (see Section 3.3). Restore files contain all the information from a molbloc EEPROM. They are intended to restore the complete molbloc EEPROM information should the EEPROM become corrupted or to return the molbloc to a known previous state.

Restore files contain molbloc header information and the molbloc calibration coefficients manipulated by **CalTool** for each gas for which the molbloc is calibrated. Restore files also contain confidential molbloc characterization information that cannot be viewed by the user. Any modifications to the restore file will make it unusable to **CalTool**. **[Tools]**, **[View molbloc Calibration]** (see Section 4.4.4) allows the public information contained in a molbloc EEPROM to be viewed.

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The default restore file name is "molbloc sn NNNN Restore.brs" where:

- molbloc sn: file label
- NNNN: the molbloc serial number
- Restore: label to identify the file as a restore file
- .brs: automatic file extension of a molbloc restore file

The default path for a molbloc restore file is "CalTool for molbloc/Restore/*.brs. If a new file location is selected while saving, all restore (*.brs) files will be saved to the selected path by default until another path selection is made.

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6. molbloc NOMINAL FLOW RANGE/SIZE DESIGNATIONS AND ACTUAL PRESSURE RANGES WITH VARIOUS GASES

6.1 molbloc SIZE AND RANGE DESIGNATIONS

Until mid-1999, molblocs were always identified by "Range". The "Range" is the molbloc's nominal full scale flow in Nitrogen (N2) at an operating pressure of 250 kPa. Actual molbloc ranges change with operating pressure and calibration gas (see the molbox Operation and Maintenance Manual, Flow Measurement Specifications). Since mid-1999, molblocs have been designated by size with a sizing code.

On molbloc EPROM's, the molbloc is still identified by its nominal range rather than by its size, therefore, **CalTool** identifies molblocs by their nominal ranges. molbloc size and range designation correspondence are given in Table 2.

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Table 2. molbloc Size and Nominal Range Designations

molbloc "NOMINAL RANGE" DESIGNATION	molbloc SIZE DESIGNATION
10 sccm	1E1
50 sccm	5E1
100 sccm	1E2
200 sccm	2E2
500 sccm	5E2
1 slm	1E3
5 slm	5E3
10 slm	1E4
30 slm	3E4

6.2 molbloc PRESSURE DEPENDENT CALIBRATION TYPES

All **CalTool for molbloc** calibrations are of the "Single P" type, meaning that they are performed at a specific upstream or downstream operating pressure. The valid molbloc range for a given gas depends on the calibration pressure.

If the calibration pressure is a molbloc downstream pressure of atmospheric pressure or a molbloc upstream pressure between 250 and 325 kPa absolute (36 and 48 psia), the molbloc is considered to have a LOW pressure calibration. molbloc ranges for various gases with low pressure calibrations are given in Table 3.

If the calibration pressure is a molbloc upstream pressure between 325 and 525 kPa absolute (47 and 76 psia), the molbloc is considered to have a HIGH pressure calibration. molbloc ranges for various gases with HIGH pressure calibrations are given in Table 4.

Extending the molbloc range beyond the ranges specified in Table 3 or Table 4, depending on their operating pressure, may result in out of tolerance measurements.

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Table 3. molbloc Ranges with Low Pressure Calibrations

	GASES		molbloc SIZE AND FULL SCALE FLOW (sccm)								
			SIZE 1E1	SIZE 5E1	SIZE 1E2	SIZE 2E2	SIZE 5E2	SIZE 1E3	SIZE 5E3	SIZE 1E4	SIZE 3E4
INERT	Nitrogen	N_2	10	50	100	200	500	1 000	5 000	10 000	30 000
	Argon	Ar	10	50	100	200	500	1 000	5 000	10 000	30 000
	Helium	He	10	50	100	200	500	1 000	5 000	10 000	30 000
	Sulfur Hexafluoride	SF_6	10	50	100	200	500	1 000	**2 000 500**	**6 000 1 000**	**6 000 4 000**
	Xenon	XE	10	40	80	150	400	800	**3 500 500**	8 000	**11 000 3 000**
FLAMMABLE	Butane	C_4H_{10}	20	100	**130 30**	**270 50**	**670 140**	2 300	**2 200 1 400**	**7 000 3 000**	-- --
	Ethane	C_2H_6	20	100	200	400	1 000	2 000	**6 000 1 000**	**18 000 2 000**	**18 000 6 000**
	Ethylene	C_2H_4	16	80	160	320	800	1 600	**7 000 1 000**	16 000	**20 000 5 000**
	Hydrogen	H_2	20	100	200	400	1 000	2 000	10 000	20 000	60 000
	Methane	CH_4	16	80	160	320	800	1 600	8 000	16 000	**40 000 5 000**
	Propane	C_3H_8	20	100	200	400	1 000	2 000	**3 000 1 000**	**10 000 2 000**	**10 000 7 000**
FLUORO-CARBONS	Carbon Tetrafluoride	CF_4	10	50	100	200	500	1 000	**4 000 600**	10 000	**12 000 3 000**
	Hexafluoroethene	C_2F_6	10	50	100	200	500	1 000	**2 000 600**	**6 000 1 200**	**6 000 4 000**
	Trifluoromethane	CHF_3	10	50	100	200	500	1 000	**4 000 600**	10 000	**12 000 4 000**
OTHER	Air	Air	10	50	100	200	500	1 000	5 000	10 000	30 000
	Carbon Dioxide	CO_2	10	50	100	200	500	1 000	5 000	10 000	**20 000 4 000**
	Carbon Monoxide	CO	10	50	100	200	500	1 000	5 000	10 000	30 000
	Nitrous Oxide	N_2O	10	50	100	200	500	1 000	5 000	10 000	**20 000 4 000**
	Oxygen	O_2	10	50	100	200	500	1 000	5 000	10 000	30 000

A bold value indicates that the maximum flow is limited by the maximum Reynolds number value of 1 200 which is reached before the normal differential pressure range is reached. In that case, the second value gives the minimum flow for which measurement uncertainty (accuracy) is a % of the measured value. With the microrange option, this value is divided by 10 (see molbloc Flow Measurement Specifications in the molbox Operation and Maintenance Manual).

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Table 4. molbloc Ranges with High Pressure Calibrations

	GASES		molbloc SIZE AND FULL SCALE FLOW (sccm)								
			SIZE 1E1	SIZE 5E1	SIZE 1E2	SIZE 2E2	SIZE 5E2	SIZE 1E3	SIZE 5E3	SIZE 1E4	SIZE 3E4
INERT	Nitrogen	N_2	20	100	200	400	1 000	2 000	10 000	20 000	**40 000** **7 500**
	Argon	Ar	20	100	200	400	1 000	2 000	10 000	17 000	**35 000** **6 000**
	Helium	He	20	100	200	400	1 000	2 000	10 000	20 000	65 000
	Sulfur Hexafluoride	SF_6	25	**100** **15**	**120** **30**	**250** **50**	**600** **150**	**2 000** **300**	**2 000** **1 400**	**6 200** **2 800**	-- --
	Xenon	XE	20	100	150	350	650	1 700	**3350** **950**	**11 000** **1 900**	**11 000** **5 700**
FLAMMABLE	Butane	C_4H_{10}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Ethane	C_2H_6	40	200	**350** **50**	**700** **100**	**1 800** **200**	4 000	**6 000** **2 300**	**20 000** **4 500**	**20 000** **13 800**
	Ethylene	C_2H_4	40	200	350	700	2 000	4 000	**7 000** **2 000**	**22 000** **4 000**	**22 000** **12 700**
	Hydrogen	H_2	40	200	400	900	2 000	4 500	22 000	45 000	130 000
	Methane	CH_4	35	175	350	700	1 700	3 500	**13 000** **2 000**	33 000	**42 000** **12 000**
	Propane	C_3H_8	50	**200** **25**	**200** **50**	**400** **100**	**1 000** **250**	**3 500** **500**	**3 500** **2 600**	**11 000** **5 400**	-- --
FLUORO-CARBONS	Carbon Tetrafluoride	CF_4	20	100	200	400	1 000	2 000	**3 700** **1 200**	**12 000** **2 400**	**12 000** **7 300**
	Hexafluoroethene	C_2F_6	25	**100** **15**	**120** **30**	**250** **50**	**600** **150**	**2 000** **300**	**1 800** **1 500**	**6 000** **3 000**	-- --
	Trifluoromethane	CHF_3	25	125	**240** **30**	**450** **60**	**1 200** **150**	2 500	**4 000** **1 500**	**12 000** **3 000**	**12 000** **8 800**
OTHER	Air	Air	20	100	200	400	1 000	2 000	10 000	20 000	**40 000** **7 200**
	Carbon Dioxide	CO_2	25	125	250	500	1 250	2 500	**6 600** **1 400**	**20 000** **2 500**	**20 000** **8 800**
	Carbon Monoxide	CO	20	100	200	400	1 000	2 000	10 000	20 000	**40 000** **7 500**
	Oxygen	O_2	20	100	200	400	1 000	2 000	10 000	20 000	**40 000** **6 500**
	Nitrous Oxide	N_2O	25	125	250	500	1 250	2 500	**11 000** **1 500**	**20 000** **3 000**	**20 000** **9 000**

A bold value indicates that the maximum flow is limited by the maximum Reynolds number value of 1 200 which is reached before the normal differential pressure range is reached. In that case, the second value gives the minimum flow for which measurement uncertainty (accuracy) is a % of the measured value. With the microrange option, this value is divided by 10 (see molbloc Flow Measurement Specifications in the molbox Operation and Maintenance Manual).

Where there is no value in the table (-), this indicates that the maximum Reynolds number is reached before the differential pressures reaches 5 kPa, therefore calibration with that gas is not useful.

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7. GLOSSARY

% Reading Error	The disagreement of the DUT and the reference expressed as a % of the reference reading. ((DUT – reference)/reference) * 100.
Absolute	As in "absolute pressure". Pressure expressed relative to vacuum.
β (Beta)	One of the molbloc calibration coefficients manipulated by **CalTool for molbloc**. The slope of the variation of C_G with Reynolds number.
$C_{G(re)}$	One of the molbloc calibration coefficients manipulated by **CalTool for molbloc**. Geometry of the molbloc flow path and Reynolds number dependence.
Calibration Gas (Test Gas)	The gas species flowed in a calibration or verification test. The gas with which the molbloc is being calibrated.
Calibration Test	A test run by **CalTool for molbloc** that collects readings from a molbloc and a mass flow standard, stores the readings in a data file (*.dat) and goes directly to the calculate and activate calibration functions at the end of the test. Calibration tests are run with the intention of calculating new molbloc calibration coefficients.
Downstream	Location of point A relative to point B in a flow system in which point A is at a different location in the direction of the flow. For example, the downstream molbloc pressure port is downstream relative to the upstream pressure port because it is at a different location from the upstream port in the direction of the flow.
DUT	Device Under Test. The device being tested or calibrated.
Full Mod Calibration	A molbloc calibration option which is valid over a range of operating pressure.
Fixed Measurement Cycle Flow Standard	A mass flow standard whose operating principle requires measurement of volume or pressure change over a period of time.
FS	Abbreviation of "full scale". The full scale value is the maximum value or the span of a measurement range. Limits and specifications are often expressed as % FS.

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Gauge	As in "gauge pressure". Pressure expressed relative to atmospheric pressure.
K Factor	A factor representing the relationship between the process gas and a surrogate gas for a DUT.
Operating Pressure	The average pressure at which the molbloc is operated (average of upstream and downstream pressure) or, if the molbloc pressure is held constant by an upstream or downstream regulator, the value of the constant pressure.
Process Gas	The gas for which a device under test is to be characterized or calibrated. The gas that will actually flow in the device under test when it is used in a process.
PRT	Platinum Resistance Thermometer. The element used in molblocs to measure temperature.
Psia	Pressure unit "pounds per square inch absolute". Pressure expressed relative to vacuum.
Psig	Pressure unit "pounds per square inch gauge". Pressure expressed relative to atmospheric pressure.
Rate	A molbox DISPLAY function in which the current rate of change of the flow in flow units/second is displayed. A measure of stability of the flow used by the molbox to make the ready/not ready determination. See also **Stability Limit**.
Ready/Not Ready	Indication of when flow is stable within the stability limit. See also **Stability Limit**.
Reynolds Number	A ratio of the inertia forces to the viscous forces in a flowing fluid. This dimensionless number, which is dependent on fluid viscosity, density, velocity and length of the flow field, is often used to predict a boundary point between laminar and turbulent flow regimes.
RPT	Reference Pressure Transducer. The pressure transducers used in molbox1 and molbox RFM are referred to as RPTs.
Single P Calibration	A molbloc calibration option which is valid at a single specified operating pressure.
Stability Limit	A limit expressed in units of flow per second (e.g., sccm/second). The stability limit is used as the *Ready/Not Ready* criterion *Ready (**<*>**)* if rate is less than stability limit, *Not Ready* (**<↑>** or **<↓>**) if rate is greater than stability limit. See also **Rate**.

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Surrogate Gas	A gas whose behavior, from the standpoint of a device under test, is similar to the process gas for which the device is to be characterized and used. A surrogate gas is often used in calibration and testing when the process gas cannot be used for safety or cost reasons.
Test Pressure	The pressure at which the molbloc is being calibrated and will be used. To use **CalTool** properly, the test pressure must be a constant upstream or downstream value within the limits of the molbloc pressure dependent calibration options. See the molbloc pressure dependent calibration types and ranges in Section 6.
Upstream	Location of point A relative to point B in a flow system in which point A is at a different location in the opposite direction of the flow. For example, the upstream molbloc pressure port is upstream relative to the downstream pressure port because it is at a different location from the downstream port in the opposite direction of the flow.
Verification Test	A test run by **CalTool for molbloc** that compares readings from a molbloc and a mass flow standard and creates a data file (*.dat) but does not go directly to the calculate and active calibration functions at the end of the test. Verification tests are run with the intention of verifying a molbloc calibration.
Volumetrically Based Mass Flow Units	Mass flow units of measure that are based on the quantity of gas that occupies a fixed volume under reference pressure and temperature conditions.

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NOTES

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